

TWR-61241

AFT SEGMENT DOME-TO-STIFFENER FACTORY JOINT
INSULATION VOID ELIMINATION

FINAL REPORT

MARCH 1991

Prepared for:

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, ALABAMA 35812**

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***Thiokol* CORPORATION**
SPACE OPERATIONS

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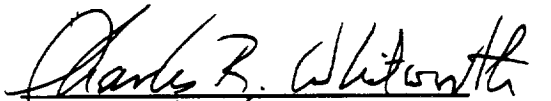
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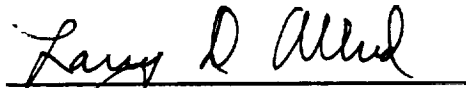
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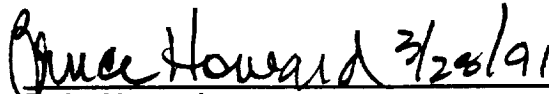

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1.0 INTRODUCTION

Since the detection of voids in the internal insulation of the dome-to-stiffener factory joint of the 15B aft segment, all aft segment dome-to-stiffener factory joints have been x-rayed and all were found to contain voids. This engineering study, using a full-scale process simulation article (PSA), was intended to demonstrate that the proposed changes in the insulation layup and vacuum bagging processes will greatly reduce internal insulation voids in the dome-to-stiffener factory joint.

This report presents the results of incorporating the proposed changes in the PSA-8 full-scale aft segment. The testing was conducted as outlined in WTP-0255 Rev. A.

2.0 OBJECTIVE

The objective of this study was to demonstrate that the proposed changes in the internal insulation layup and vacuum bagging processes over the aft dome-to-stiffener factory joint reduced or eliminated voids without adversely affecting the configuration or performance of the insulation which serves as a primary seal over the factory joint.

3.0 SUMMARY

The PSA-8 aft segment was insulated and cured using standard production processes except for the process and material changes mentioned in the discussion section of this report.

The cured insulation surface looked good with minimal pattern cloth wrinkle impressions. Most ultrasonic thickness measurements of the factory joint region were within the history thickness ranges, except some measurements at the 56-inch stations in the section where the additional 0.200-inch ply over the clevis leg was not used fell slightly below the history thickness ranges at seven of the degree measurement stations (Appendix A). There was also one measurement in the 72-inch station that was lower than the 1U minimum, but within the history and engineering requirements. Pin profile gages were used to obtain the actual insulation surface configuration from the 56 station to the 72 station (Appendix B). Visual observation and these surface mapping profiles demonstrated a cured insulation surface similar to the current cured configuration.

Radiographic inspection, conducted at the standard production frequency of every three degrees, detected one void in the aft dome-to-stiffener factory insulation joint. This void was located at 246 to 249 degrees, 10.58-inches aft of the tip of the inner clevis leg. The X-ray Supplement Data Sheet is provided as Appendix C.

The insulation was removed from the factory joint region, extending 14.5 inches forward and 16 inches aft of the inner clevis tip (full circumference) and dissected into approximately one-inch strips. Visual examination and measurement of defects within these strips revealed five voids. One void was determined to be the same void as detected by x-ray. All measurements of this void, except the circumferential dimension, were comparable. Radiographics reported the circumferential dimension to be 7.36 inches and visual inspection determined it to be 1.0 inches. Radiographic circumferential measurements are recognized to exaggerate the circumferential extent of defects. Any defect detected in an exposure is considered to extend half way to the next exposure until it moves from tangent. The other four voids identified in the factory joint region were randomly located and were very small (smaller than what could normally be expected to be detected by x-ray). The location and dimensions of these voids are provided as Appendix D. The last fifteen flight aft segments have had an average of 38 voids per segment detected by x-ray in this region.

Profile evaluation of the stiffener-to-stiffener region demonstrated the lengthened ramp angle which was accomplished to reduce erosion on the forward face of this joint. Ultrasonic thickness measurements fell within the lower flight history measurements for the same stations except one measurement at the 192.5 station which was less than flight history, but over the 1U and engineering requirements (Appendix A).

Since these changes indicate a reduction in the number of voids and the size of resulting voids, it is recommended that the changes implemented in this segment be incorporated into production aft segments.

4.0 CONCLUSIONS

1. The insulation process improvements demonstrated on the PSA-8 produce an insulation configuration similar to the current configuration and meet all engineering requirements.
2. The proposed changes reduce the quantity and size of the voids in the factory joint insulation.
3. The proposed changes are more consistent and repeatable than the current process.

5.0 RECOMMENDATIONS

It is recommended that:

1. The changes demonstrated in the PSA-8 aft segment be implemented into production aft segments.
2. When 20-oz breather is used, it should be removed in conjunction with the patterning cloth.

6.0 DISCUSSION

Several changes were made in the uncured insulation layup of the dome-to-stiffener factory joint region. The changes in the insulation layup operations were:

1. Skive the 0.200-in. thick circumferential ends of the pattern strips laid in the dome-to-stiffener joint region to reduce potential air entrapment.
2. Create a smoother layup at the case clevis transition area by ending and skiving the plies at the aft edge of the clevis leg to prevent bridging or lifting within the rubber plies during rubber layup and autoclave cure.
3. Lengthen the angle of the ramp over the factory joint to reduce the chance of vacuum bag bridging by increasing the pattern step length from the current 0.25-in. to 0.5-in. steps.
4. Terminate the 0.050-in. cap ply over the factory joint insulation before the ramps to allow entrapped air in the layup an easier escape route.
5. An additional 0.200-in. ply was laid over the clevis leg for 180 degrees to assure that insulation thicknesses were met.

Minor changes in the rubber layup of the stiffener-to-stiffener factory joint region were:

1. To lengthen the angle of the forward ramp. The pattern step up was increased from 0.100-in. to 0.200-in.
2. Skive the ends of the 0.200-in. thick patterns that form the ramp.

None of these layup changes created any problems to the manufacturing personnel performing the layup operations.

Other changes conducted in this study were:

1. Splitting the patterning cloth and the Chickopee cloth over the dome-to-stiffener factory joint to reduce the potential of bridging.
2. Using 20-oz breather cloth to provide a more uniform vacuum flow throughout the vacuum bag.

The vacuum bagging operations were overseen by representatives of Materials and Processes and Manufacturing Engineering. The detail of splitting and installing the patterning cloth and Chickopee cloth were determined and noted by these representatives. A detailed sketch of the installation of these materials has been prepared and will be provided with each CPI when this change is implemented into Production

Operations. More tackifier was required to hold the 20-oz polyester breather cloth in the segment than what is normally required to hold the (Stock No. 7777) Dacron breather cloth, but no other difficulties were experienced in using the 20-oz polyester breather.

Cloth removal after cure determined the new polyester (20-oz) breather material does not have the strength to allow its independent removal. Therefore, the breather cloth was pulled out with the removal of the pattern cloth. Cloth removal was somewhat more difficult than during the current process cloth removal operation.

The insulation surface looked good under visual examination, surface pattern cloth wrinkle indications were minimal. Surface impressions from the tackifier used to hold the breather cloth in place were also minimal. Most ultrasonic thickness measurements of the factory joint region were within the history thickness ranges, except some measurements at the 56-inch stations in the section where the additional 0.200-inch ply over the clevis leg was not used fell slightly below the history thickness ranges at seven of the degree measurement stations (Appendix A). There was also one measurement in the 72-inch station that was less than the 1U requirement minimum but within the history and engineering requirements. Measurements at stations 40 through 75 are evaluated for the dome-to-stiffener changes although most of those stations would not be directly affected by the changes implemented in this report.

X-ray inspection of the insulation in the dome-to-stiffener factory joint was conducted every three degrees. One void was detected in the insulation from 246 to 249 degrees. This void was reported to have a circumferential length of 7.36 inches, an longitudinal length of 1.42 inches, a radial depth of 0.026 inches and was located 10.58-inches aft of the inner clevis leg tip (Appendix C).

The insulation from the factory joint region, extending 14.5-inches forward and 16-inches aft of the inner clevis tip (full circumference) was removed from the segment at H-7, after which the samples were sent to Z-12 and cut into approximately one-inch wide strips running longitudinally to the segment. These strips were then examined in detail. Five voids were detected, with the first being the same one that was detected by x-ray. Location and all dimensions were approximately the same as the void detected by x-ray. Radiographics reported the void to be 7.36-inches circumferentially and visual inspection determined it to be 1.0-inches circumferentially. The other four voids were very minimal in size and randomly located (smaller than what could normally be detected by x-ray [Appendix D]).

NOTE

The longitudinal location measurement of the x-ray detected void is measured to the factory joint tang. The visual detected voids are measured to the inner clevis leg. The difference is 4.02 inches.

Pin profile thicknesses were conducted between station 56 and 72 to provide the exact insulation surface thickness measurements for the forward face of the joint region. These profiles were taken at the same degree locations as the standard ultrasonic insulation thickness measurements. The resulting pin gage profiles are provided as Appendix B. The profiles are comparable to the previous cured insulation configuration (which demonstrate a rounding of the lower and upper radii) of the forward edge of the factory joint.

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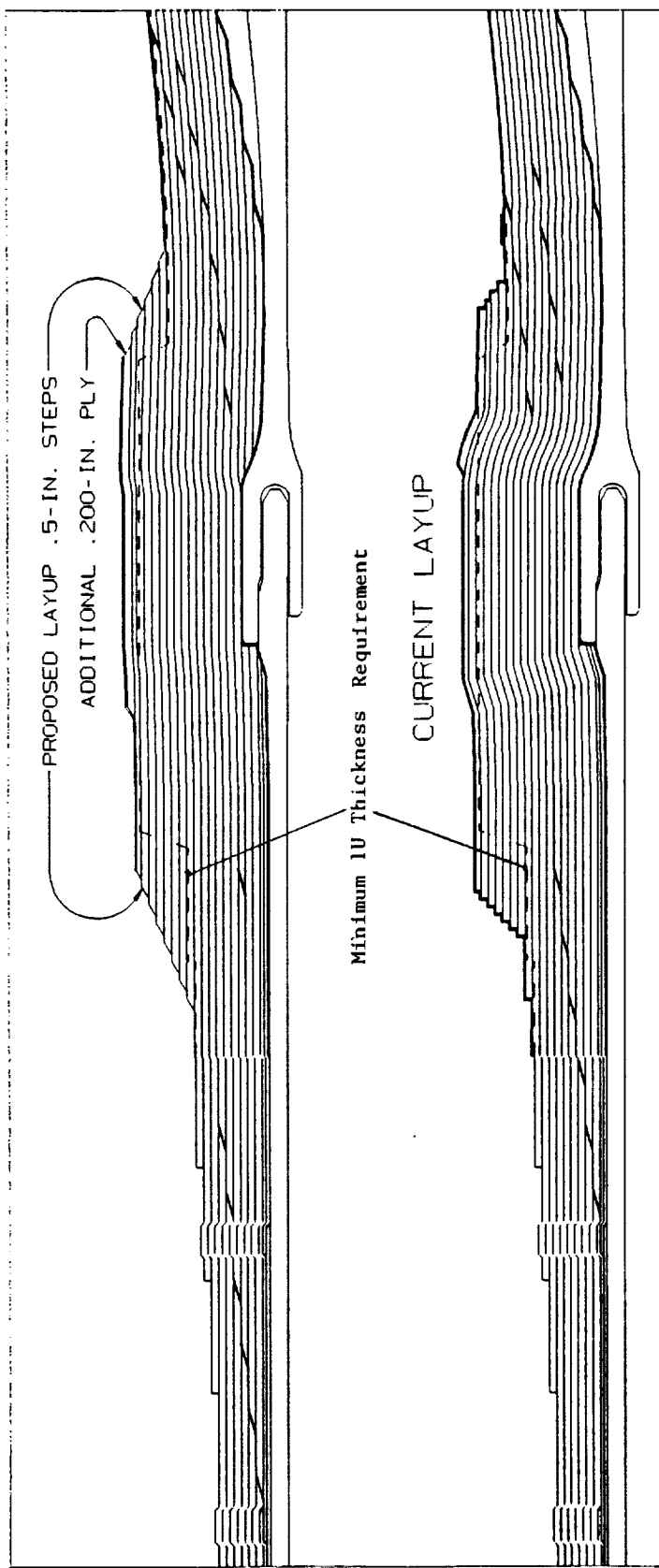


Figure 1. Current And Proposed Layup Configuration

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APPENDICES

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Appendix A. Ultrasonics Thickness Measurements

DOME TO STIFFENER REGION

STATION	PSA-8			THICKNESS DATA			PREFIRE			B/P		
	ACTUAL			FLIGHTS 1-19			10 MIN.			SPEC.		
	AVG	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	10 MIN.	MIN.	MAX
40	2.746	2.655	2.801	2.803	2.637	3.068	2.800	2.636	3.001	2.600	2.561	2.600
42	2.764	2.721	2.802	2.808	2.636	3.001	2.816	2.635	3.196	2.600	2.474	2.600
45	2.811	2.739	2.874	2.816	2.635	3.196	2.986	2.742	3.407	2.600	2.543	2.600
48	2.860	2.779	2.930	2.986	2.742	3.407	3.663	3.448	3.985	3.380	2.317	3.380
53	3.728	3.528	3.889	3.341	3.170	3.675	2.154	1.980	2.473	2.790	2.738	2.790
56	3.241	3.102	3.406	1.961	1.805	2.128	1.720	1.605	1.894	2.000	1.226	2.000
72	2.041	1.992	2.095	1.961	1.805	2.128	1.720	1.605	1.894	1.800	1.160	1.800
75	1.883	1.856	1.947	1.720	1.605	1.894	1.600	1.477	1.863	1.600	1.077	1.600
78	1.660	1.629	1.696									

STIFFENER TO STIFFENER REGION

STATION	PSA-8			THICKNESS DATA			PREFIRE			B/P		
	ACTUAL			FLIGHTS 1-19			10 MIN.			SPEC.		
	AVG	MIN	MAX	MEAN	MIN	MAX	MEAN	MIN	MAX	10 MIN.	MIN.	MAX
166.0	1.004	0.966	1.030	1.012	0.931	1.116	0.850	0.700	1.000	0.850	0.700	1.000
177.7	1.492	1.452	1.530	1.505	1.422	1.696	1.000	0.850	1.000	0.850	0.700	1.000
192.5	0.867	0.792	0.909	0.912	0.839	1.027	0.780	0.600	0.900	0.780	0.600	0.900
202.5	0.765	0.748	0.786	0.745	0.710	0.799	0.730	0.564	0.863	0.730	0.564	0.863

INDIVIDUAL THICKNESS PER STATION

DOME TO STIFFENER REGION

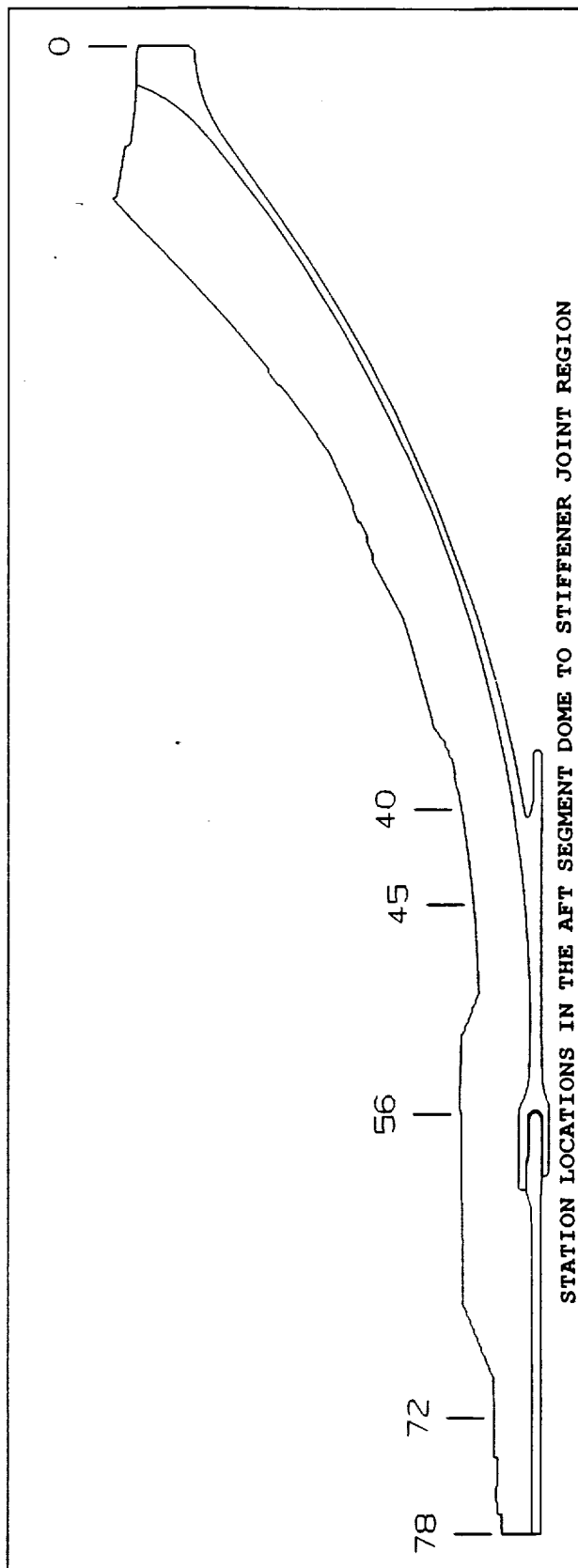
STATION	0	21.6	46.8	68.4	90	111.6	136.8	158.4	180	201.6	226.8	248.4	270	291.6	316.8	338.4
40	2.715	2.718	2.773	2.724	2.771	2.763	2.655	2.728	2.706	2.750	2.801	2.747	2.771	2.774	2.759	2.779
42	2.771	2.743	2.749	2.758	2.763	2.761	2.742	2.721	2.785	2.755	2.802	2.751	2.779	2.789	2.759	2.769
45	2.805	2.825	2.822	2.781	2.813	2.816	2.785	2.739	2.860	2.771	2.874	2.813	2.830	2.810	2.814	2.823
48	2.811	2.866	2.930	2.887	2.923	2.873	2.864	2.877	2.856	2.779	2.885	2.842	2.887	2.779	2.807	2.893
53	3.749	3.778	3.809	3.753	3.759	3.766	3.856	3.847	3.889	3.528	3.631	3.645	3.563	3.847	3.603	3.630
56	3.285	3.296	3.386	3.296	3.315	3.406	3.401	3.309	3.296	3.104	3.173	3.118	3.110	3.115	3.142	3.102
72	2.040	2.007	2.054	2.029	2.085	2.019	2.078	2.029	2.030	2.095	2.028	2.042	1.992	2.075	2.027	2.027
75	1.897	1.867	1.861	1.873	1.889	1.924	1.925	1.879	1.856	1.864	1.947	1.870	1.877	1.861	1.875	1.863
78	1.639	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652	1.652

STIFFENER TO STIFFENER REGION

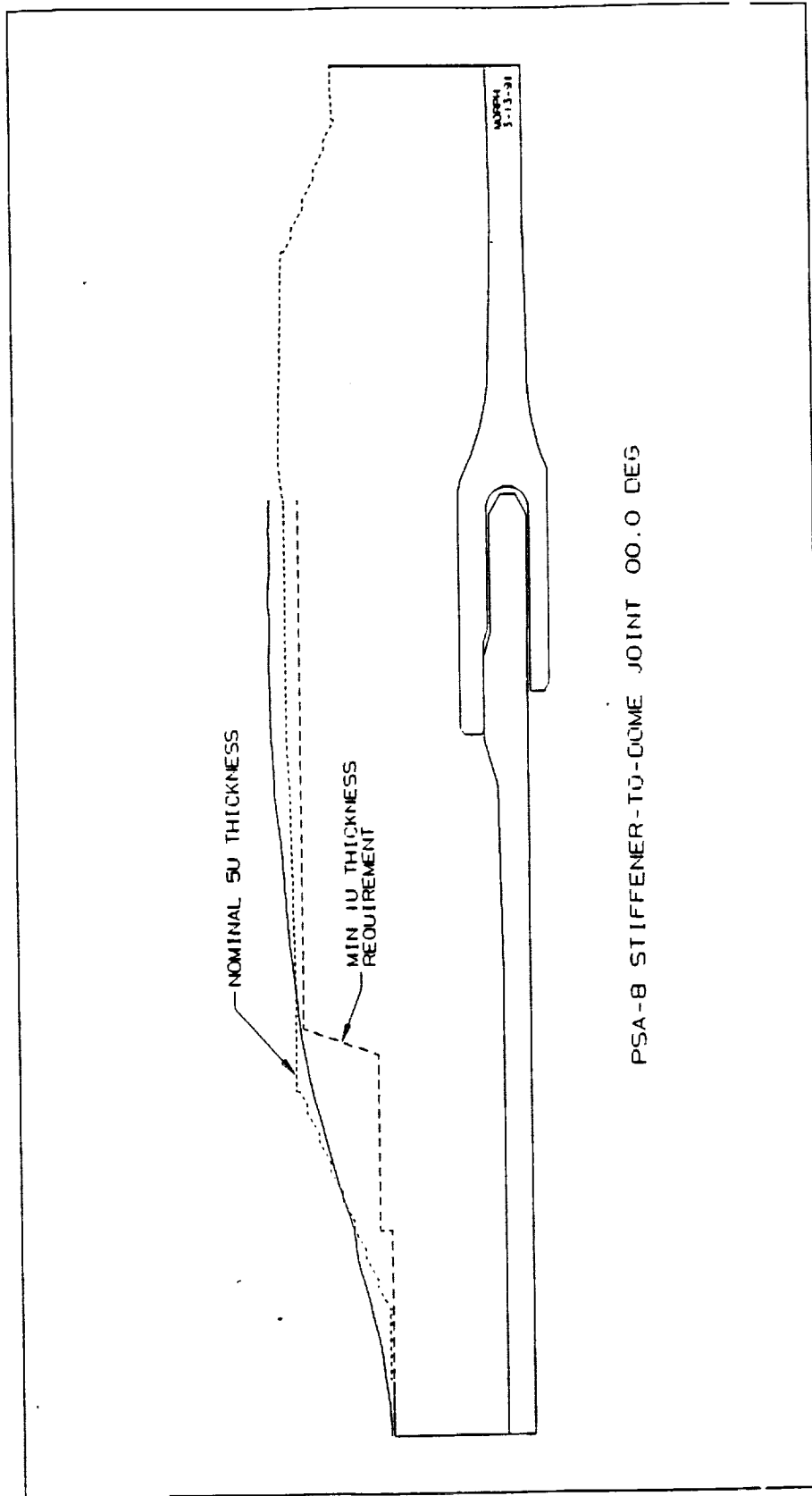
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166.0	1.017	0.966	1.012	0.994	0.985	1.017	1.008	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
177.7	1.513	1.514	1.452	1.470	1.480	1.480	1.480	1.480	1.480	1.480	1.480	1.480	1.480	1.480	1.480	1.480
192.5	0.853	0.878	0.864	0.876	0.909	0.792	0.882	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
202.5	0.748	0.786	0.767	0.766	0.775	0.760	0.761	0.760	0.760	0.760	0.760	0.760	0.760	0.760	0.760	0.760

STATION LOCATIONS WITHIN THE DOME TO STIFFENER REGION ARE PROVIDED ON THE FOLLOWING PAGE OF THIS APPENDIX

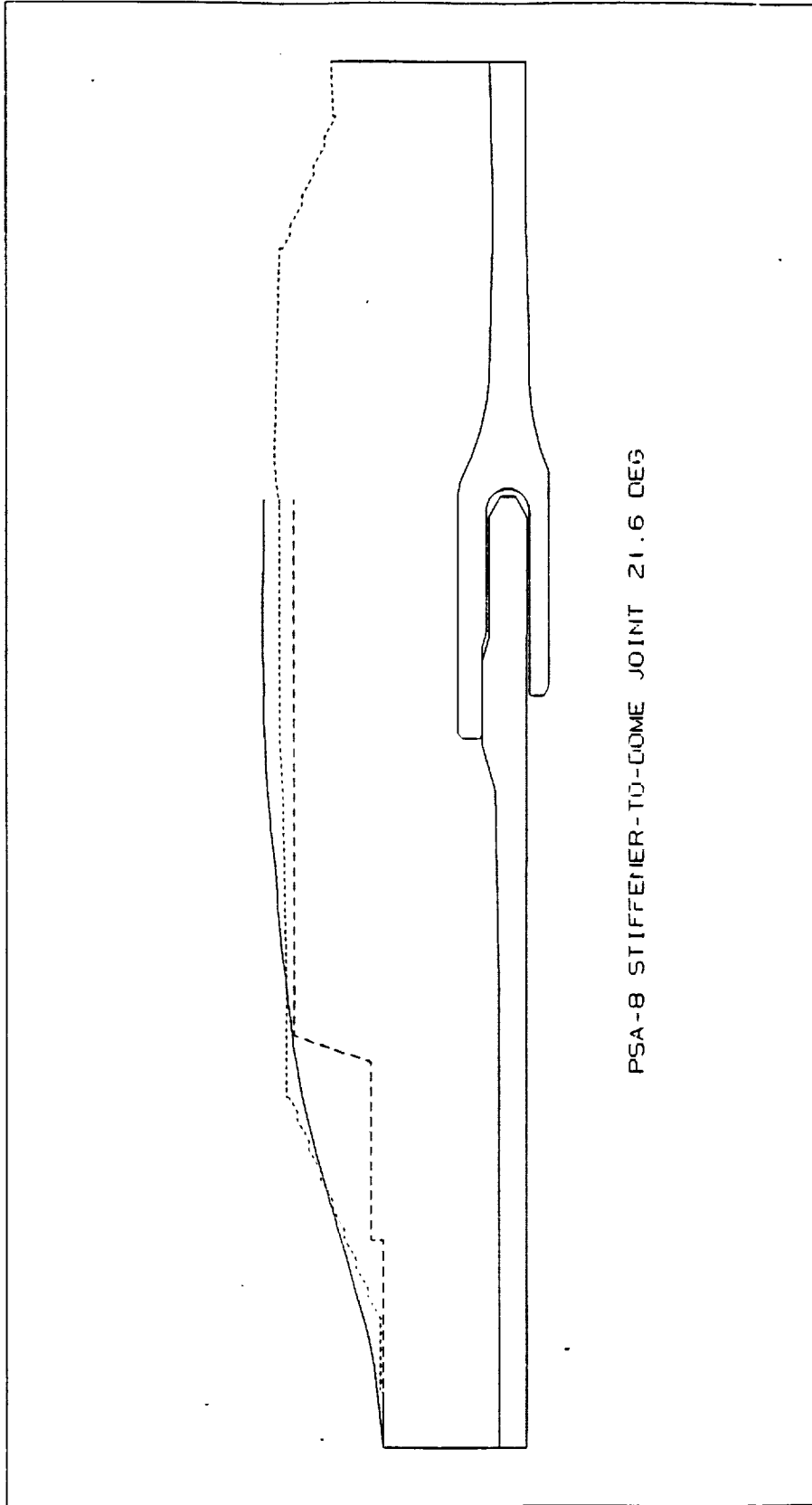
Appendix A. Ultrasonics Thickness Measurements (Continued)



Appendix B. Pin Gage Profiles



Appendix B. Pln Gage Profiles (Continued)



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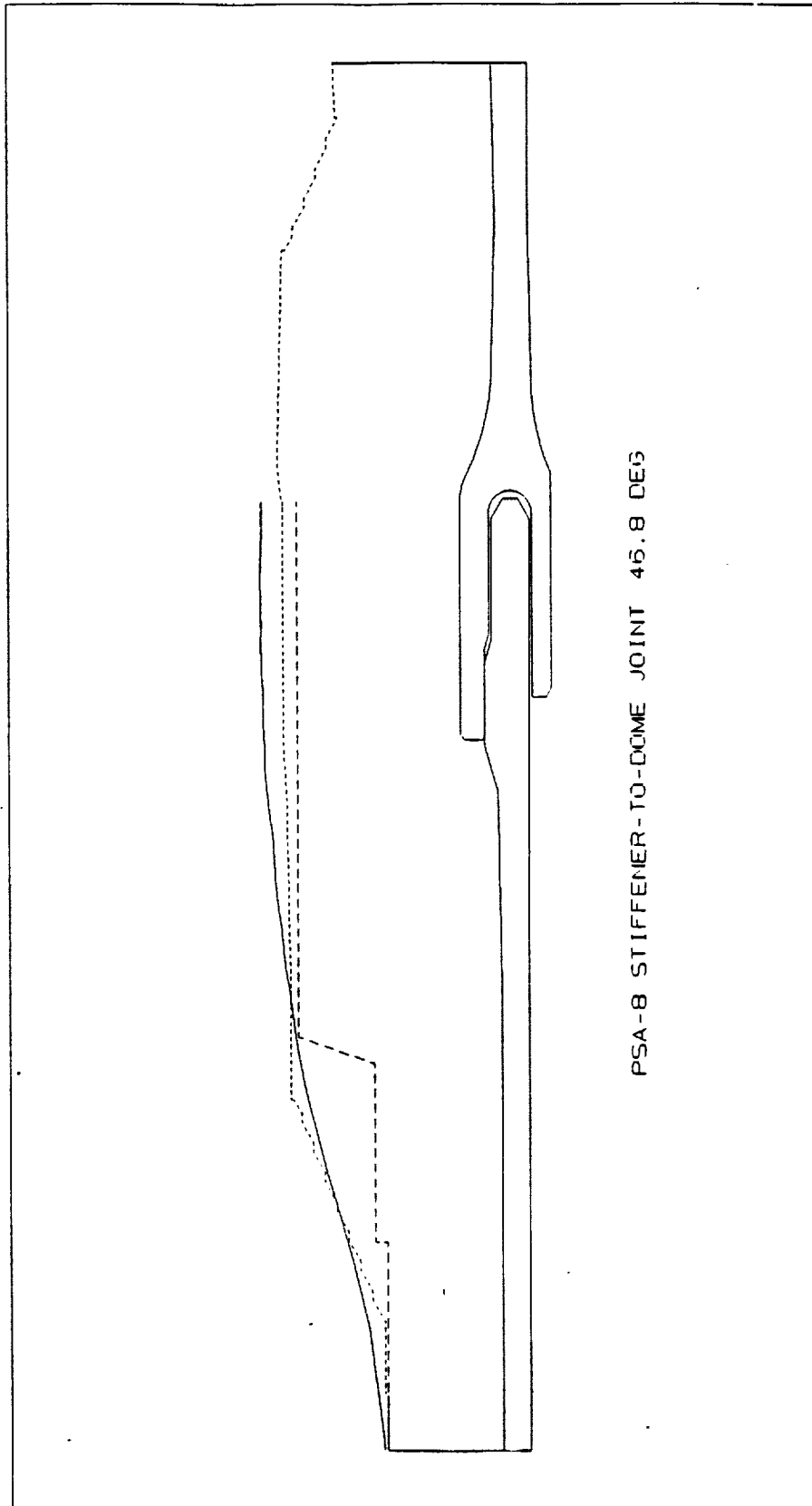
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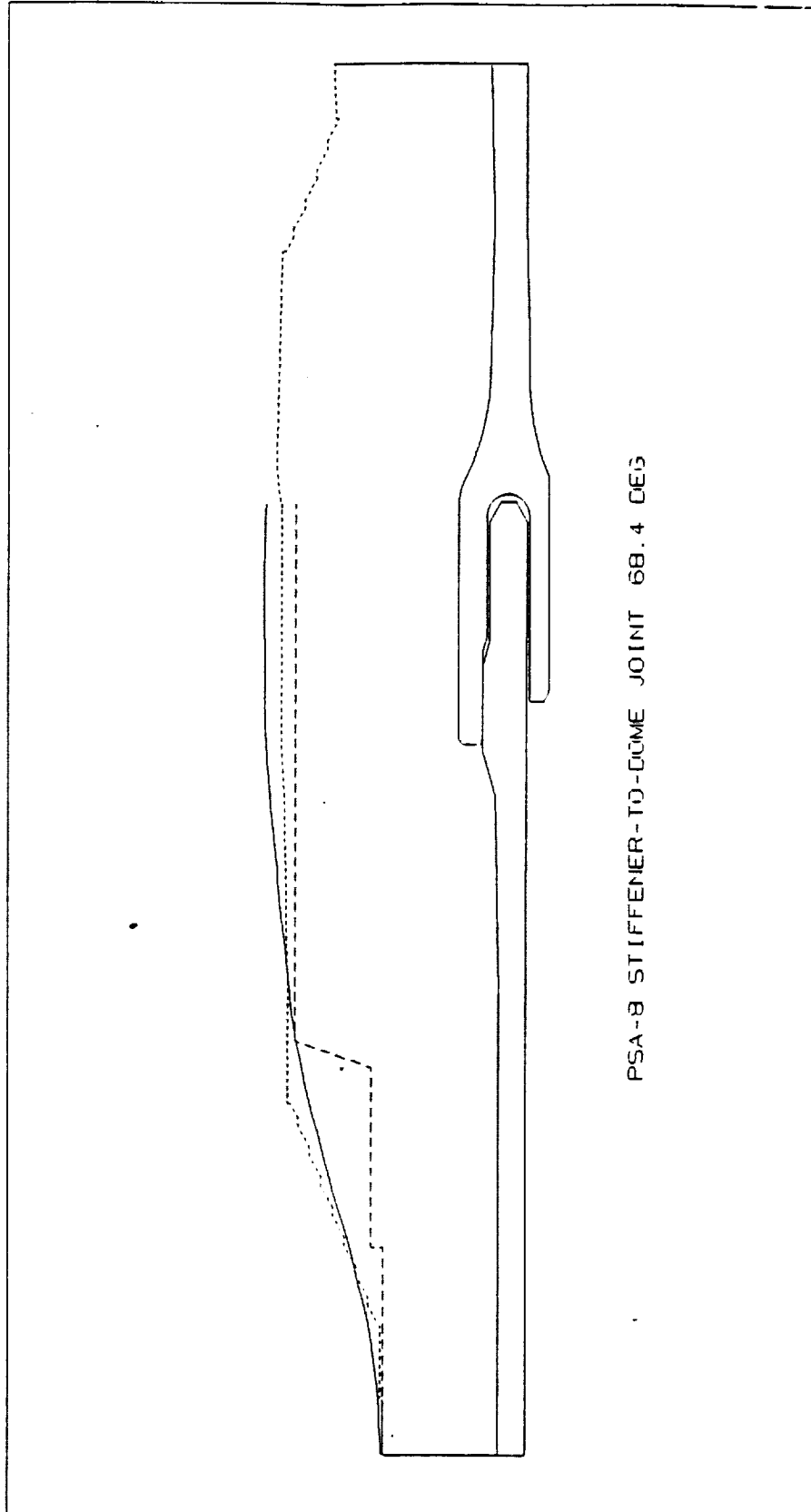
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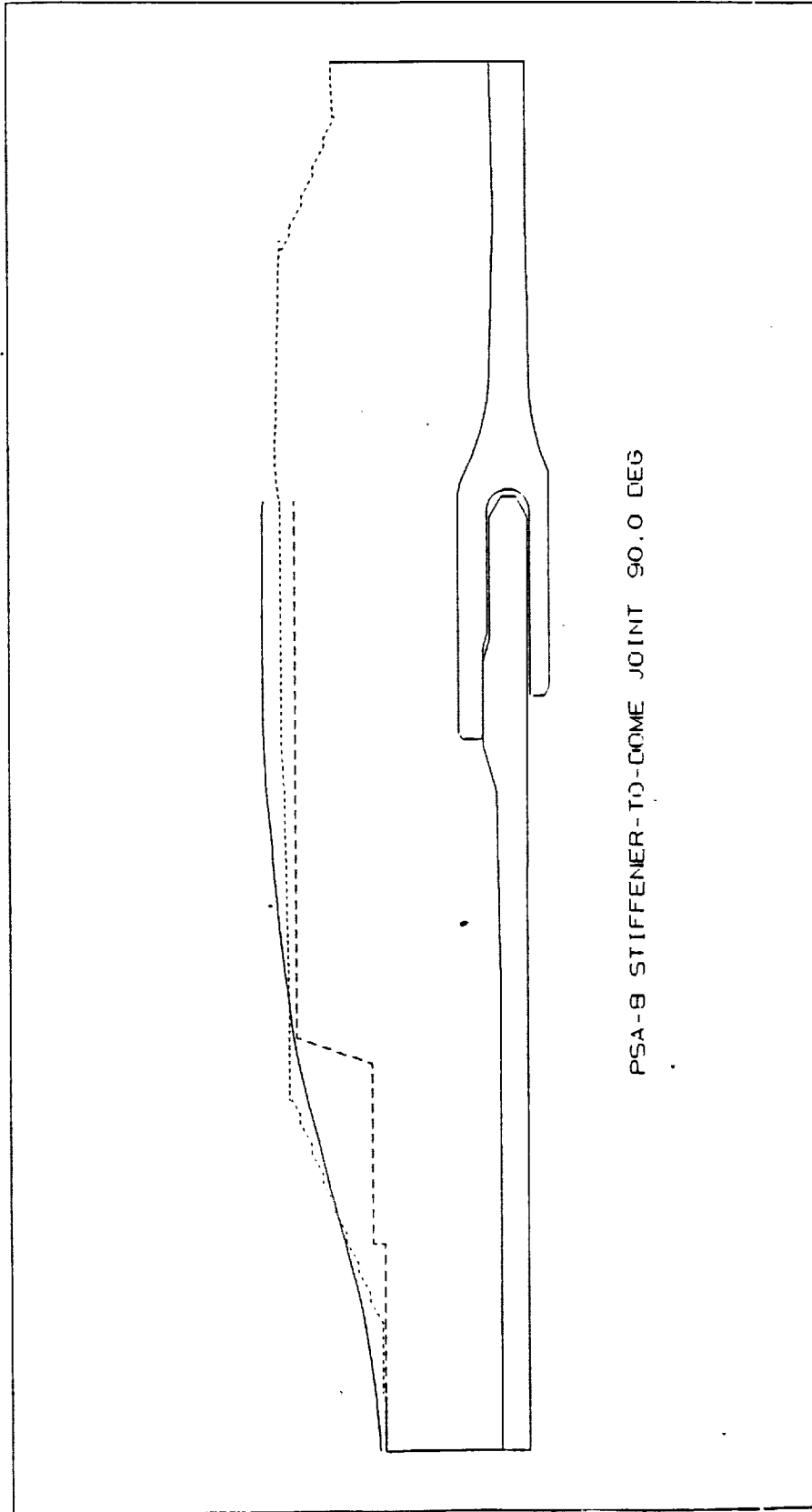
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Appendix B. Pin Gage Profiles (Continued)



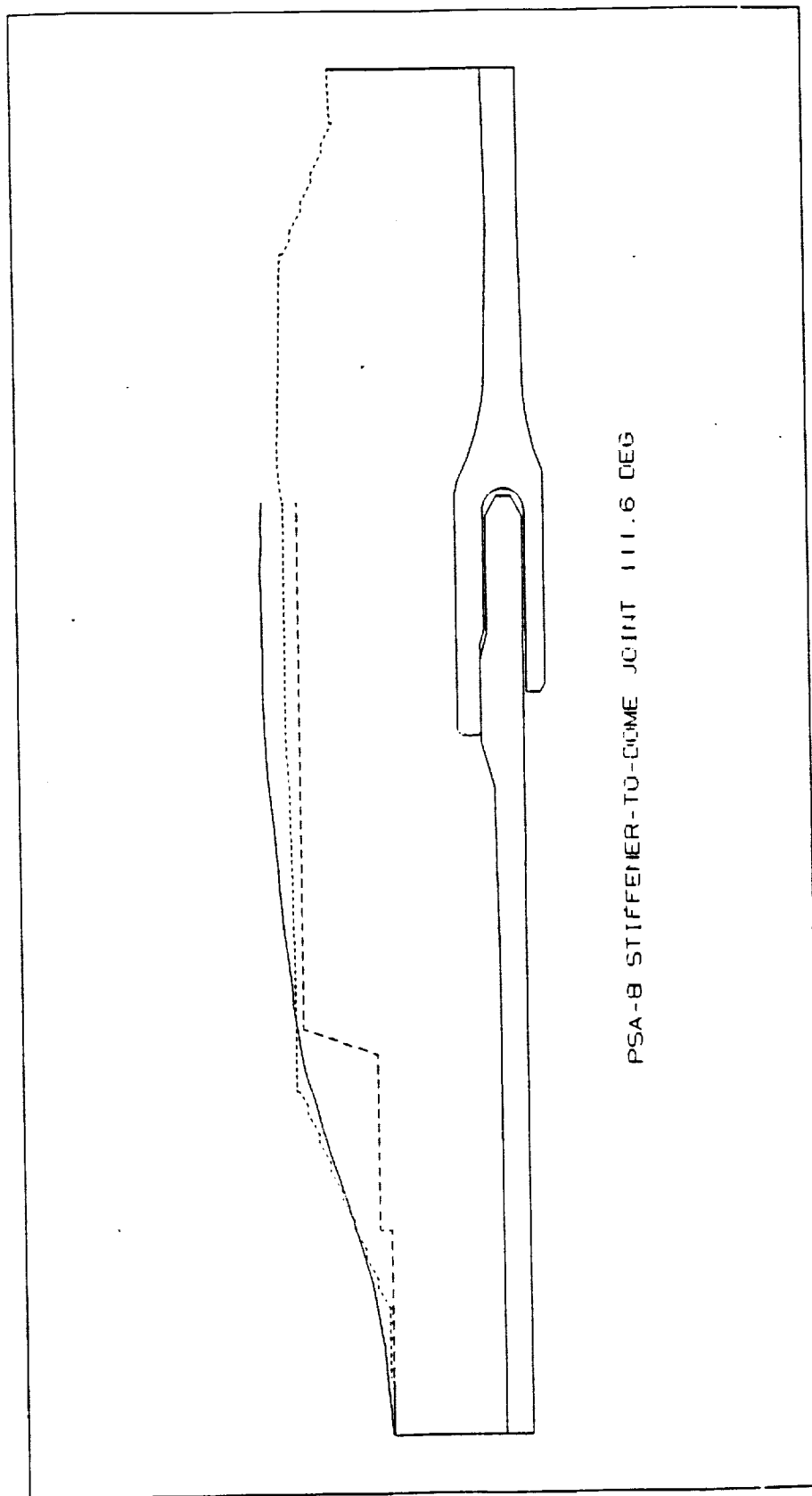
PSA-B STIFFENER-TO-DOME JOINT 90.0 DEG

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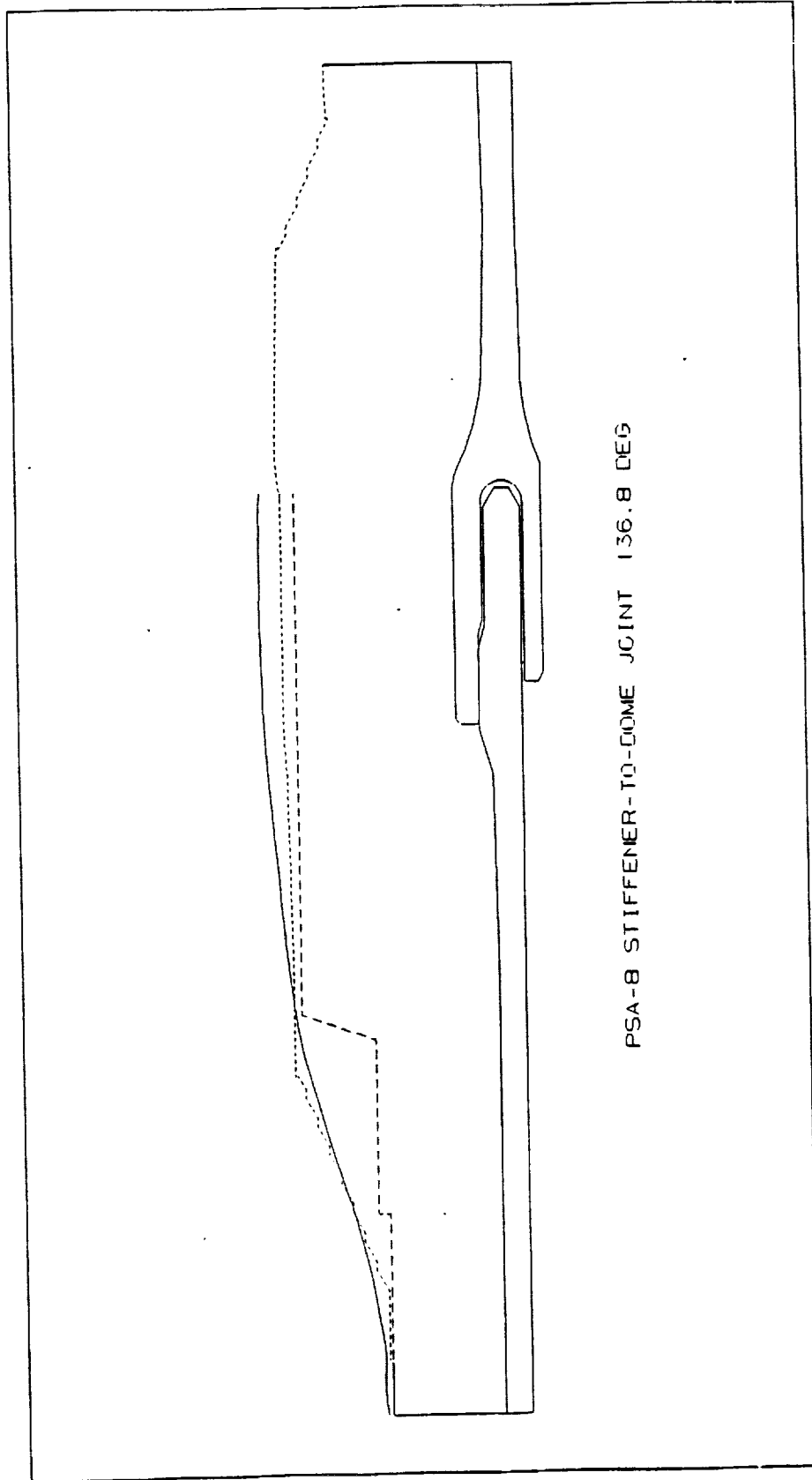
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Appendix B. Pin Gage Profiles (Continued)



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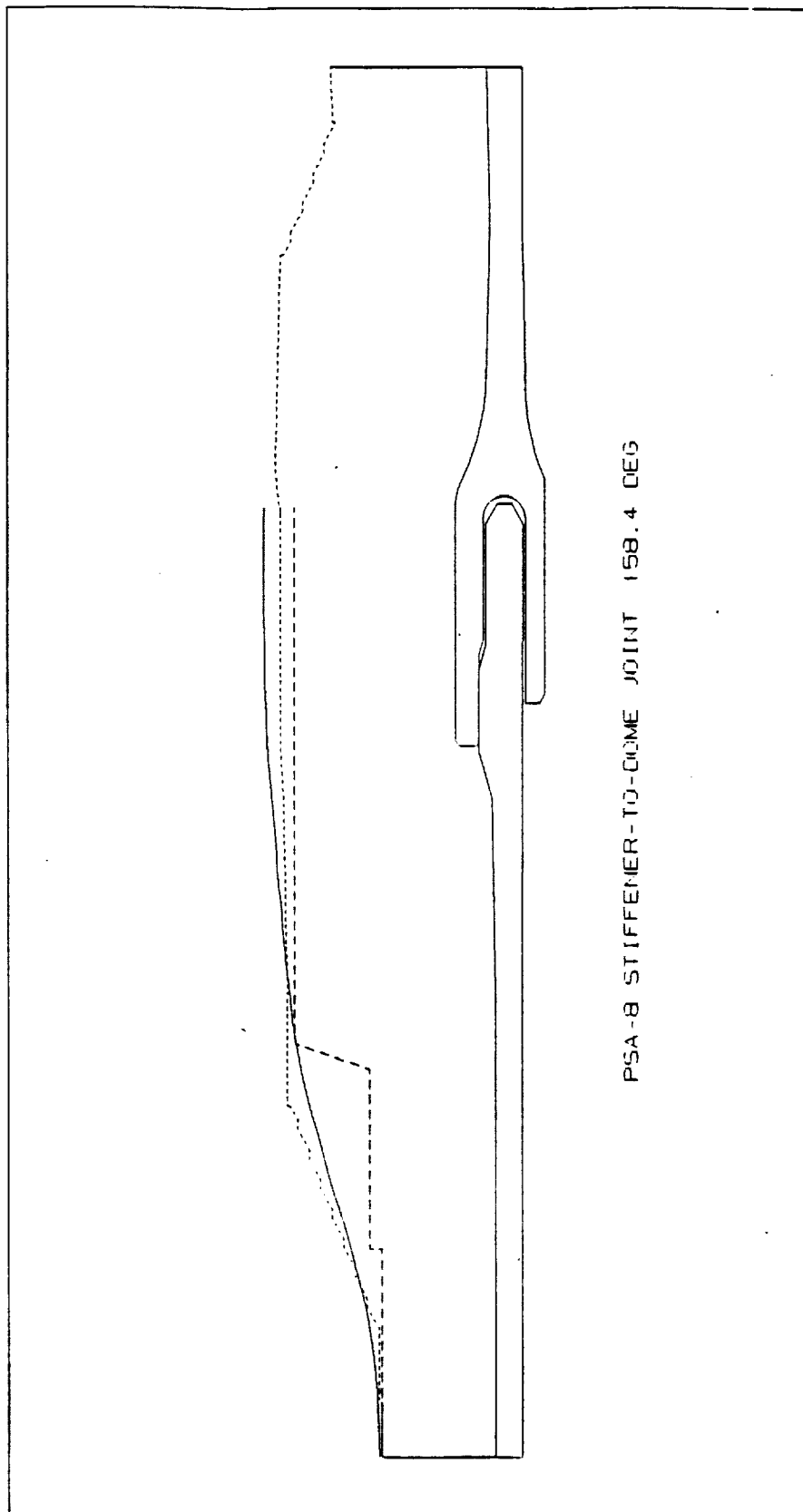
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Appendix B. Pin Gage Profiles (Continued)



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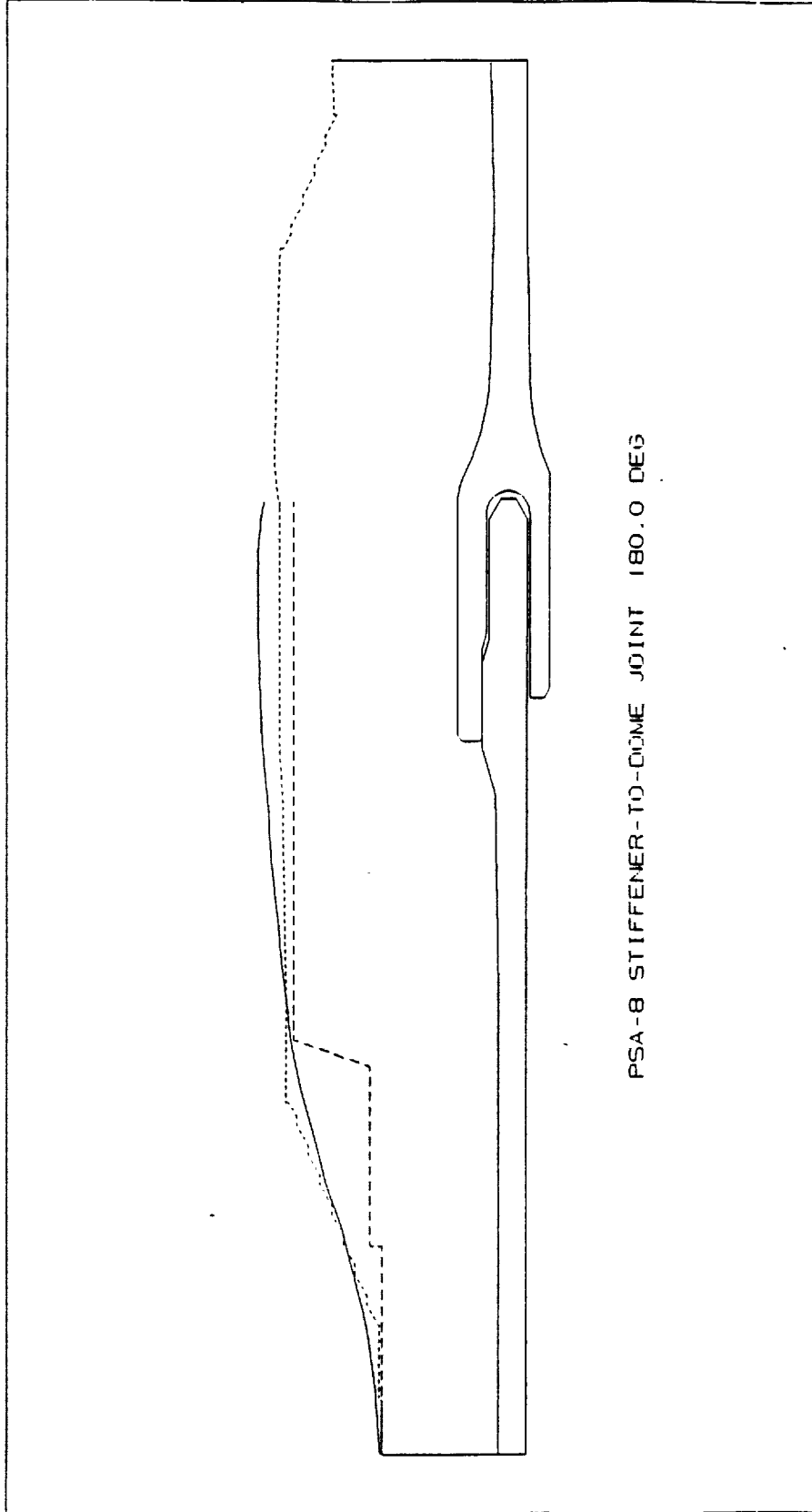
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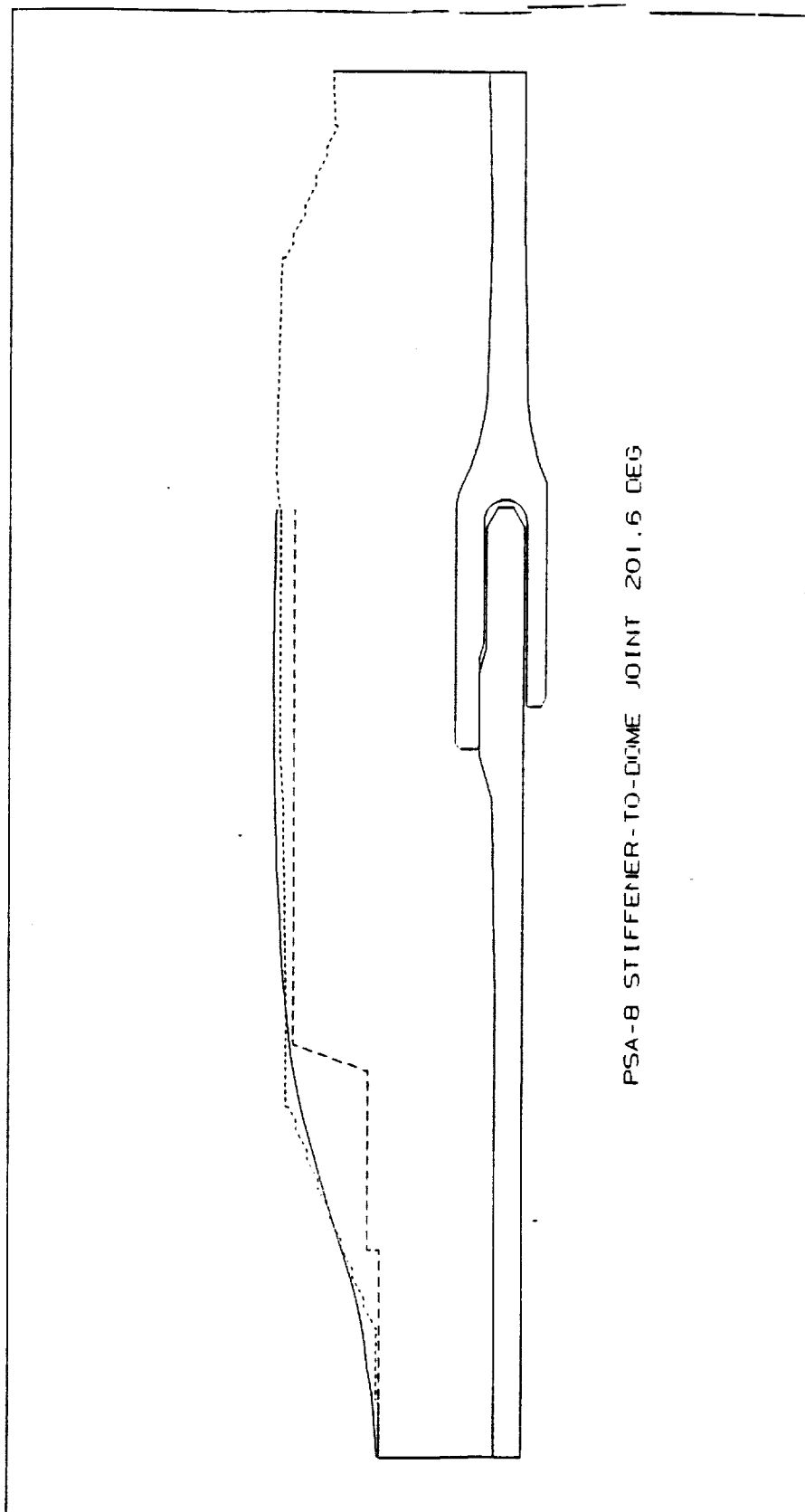


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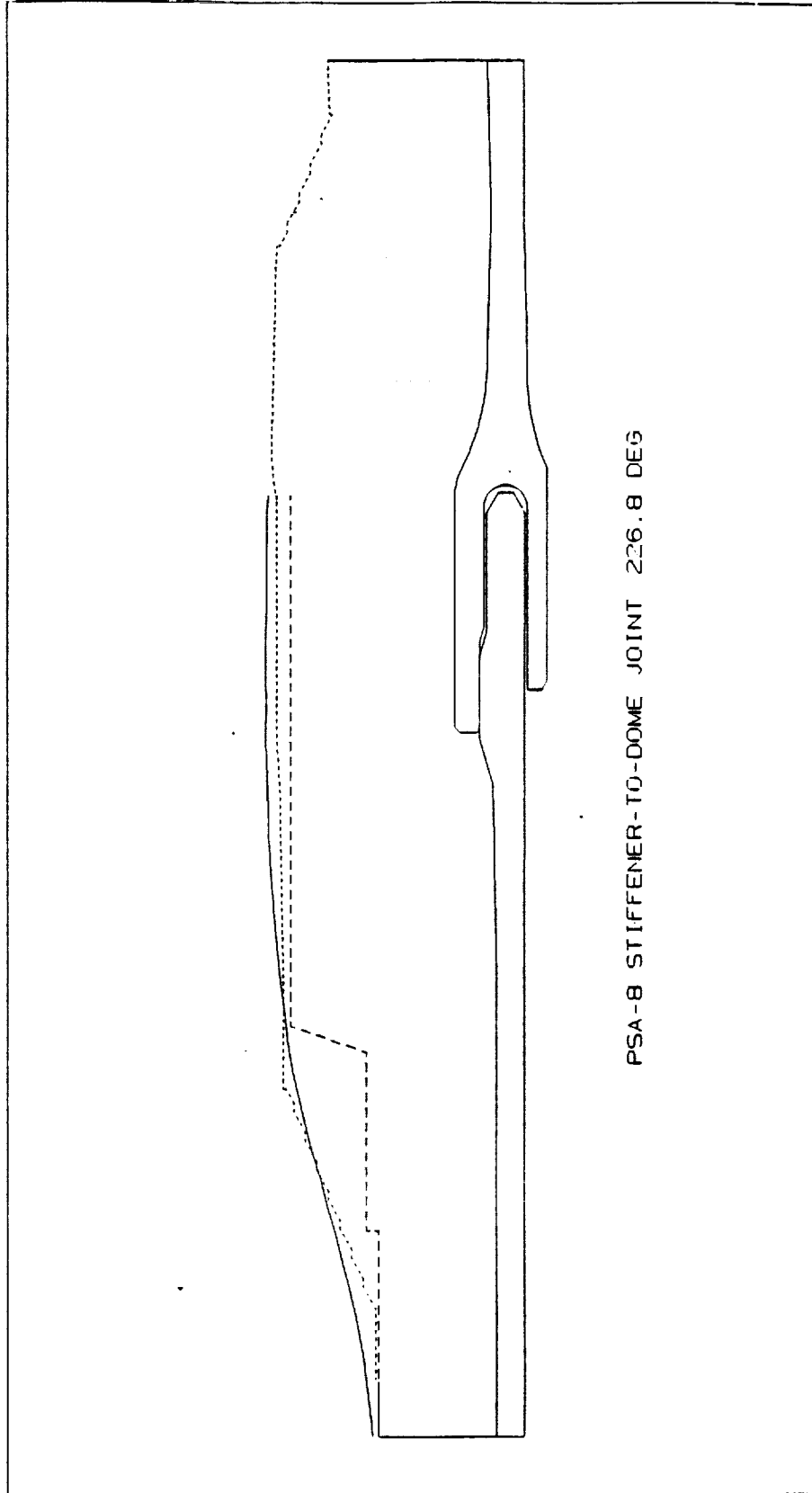
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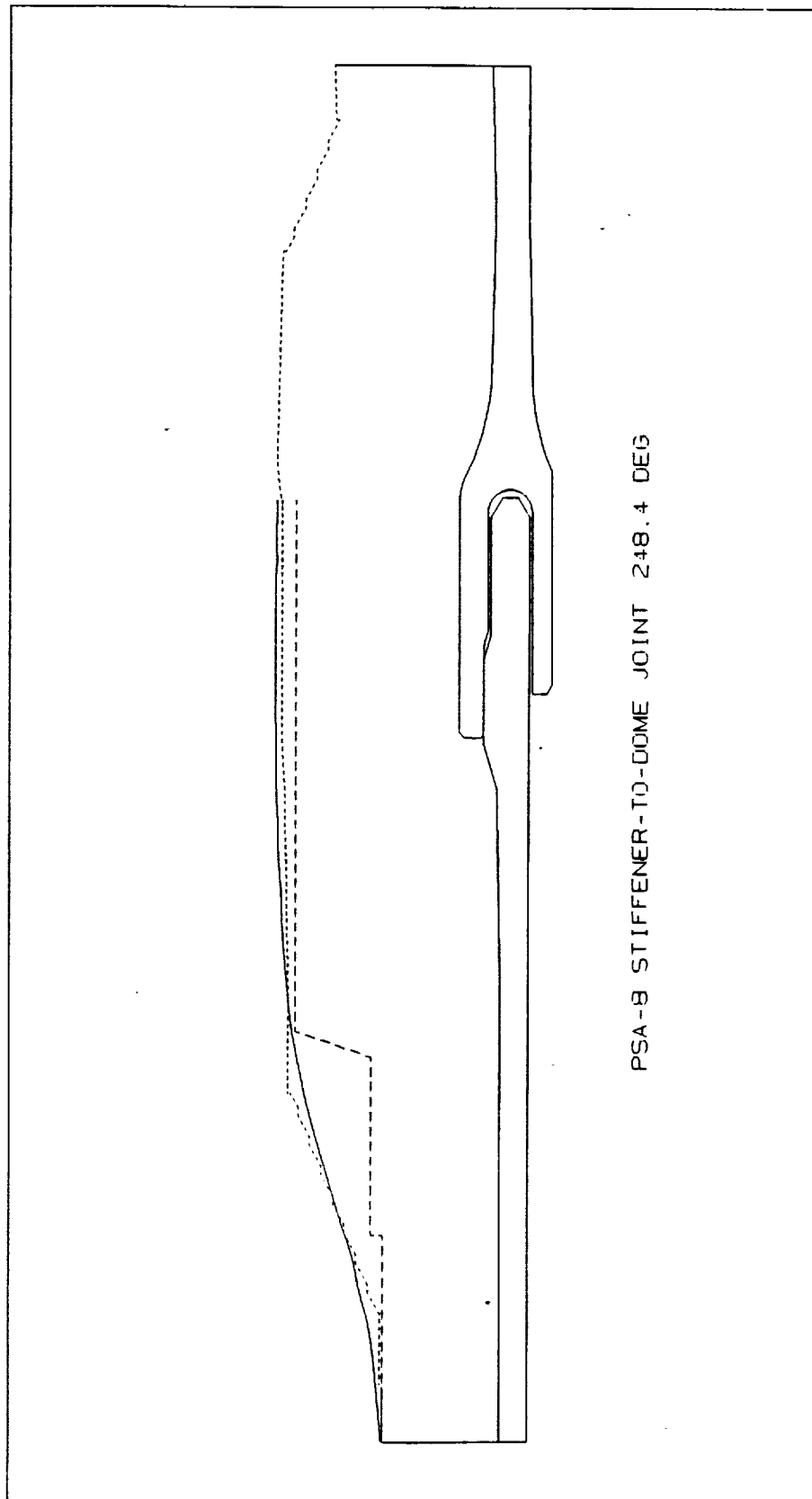
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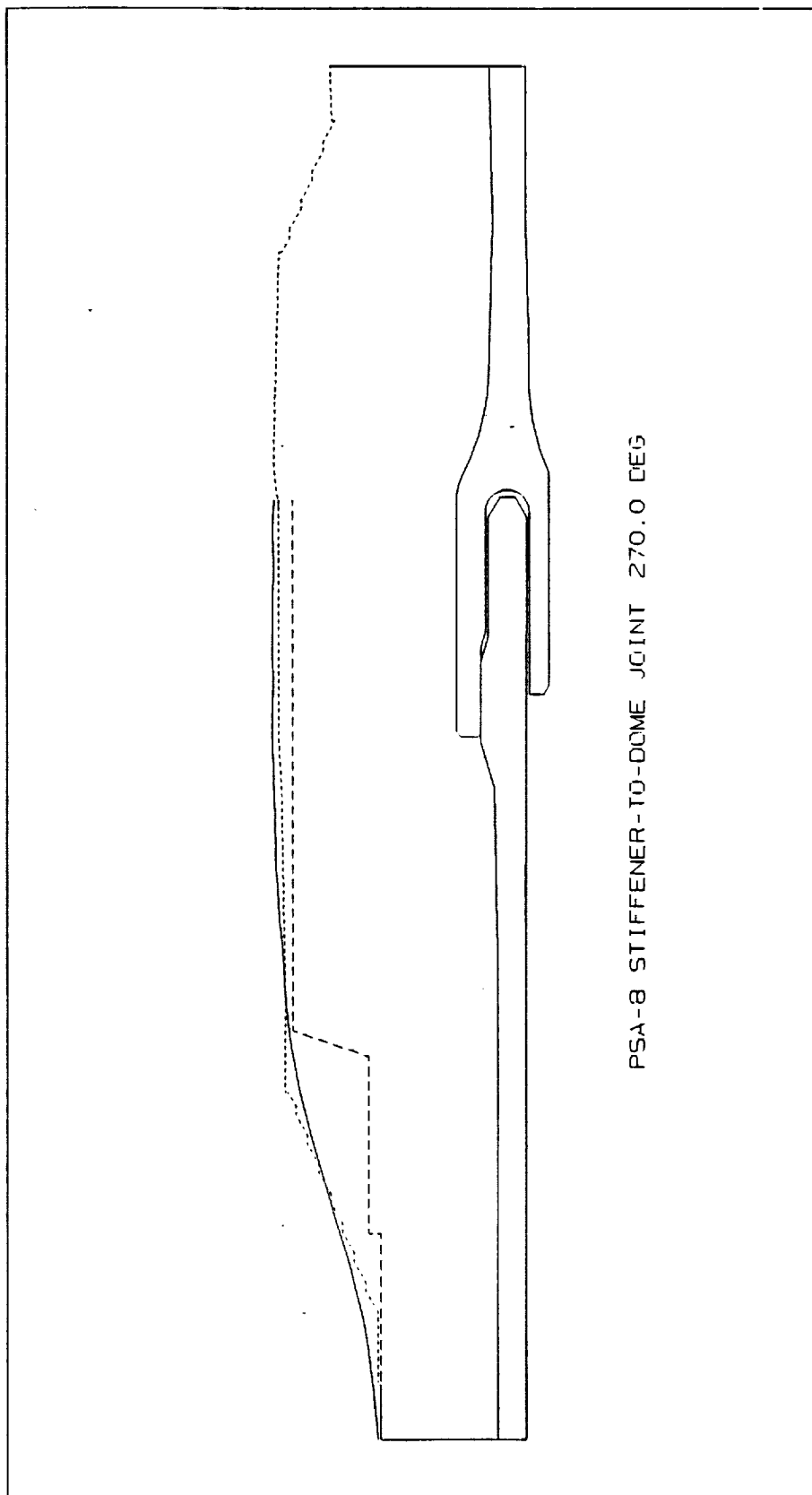
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Appendix B. Pin Gage Profiles (Continued)



Appendix B. Pin Gage Profiles (Continued)



PSA-8 STIFFENER-TO-DOME JOINT 270.0 DEG

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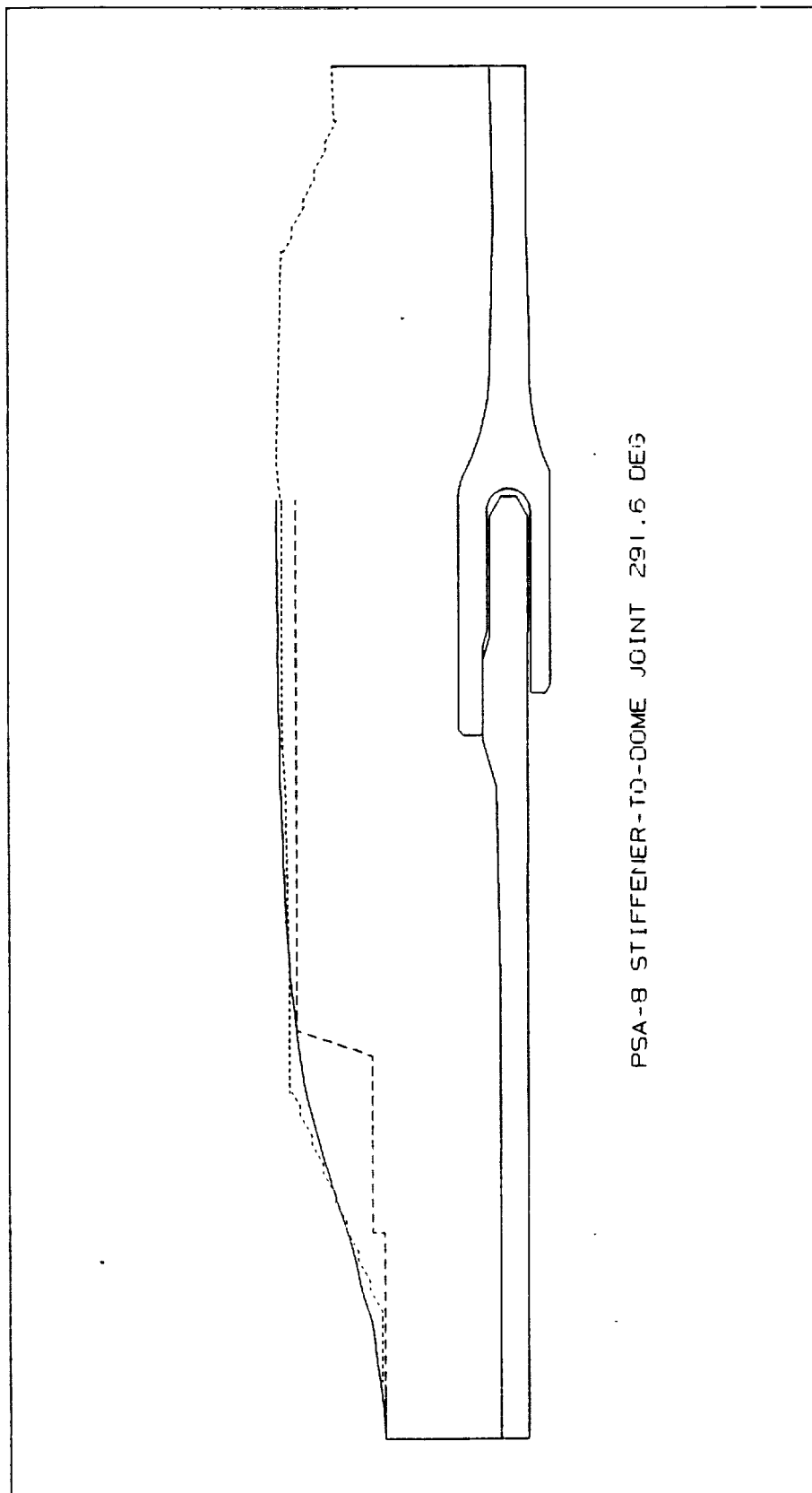
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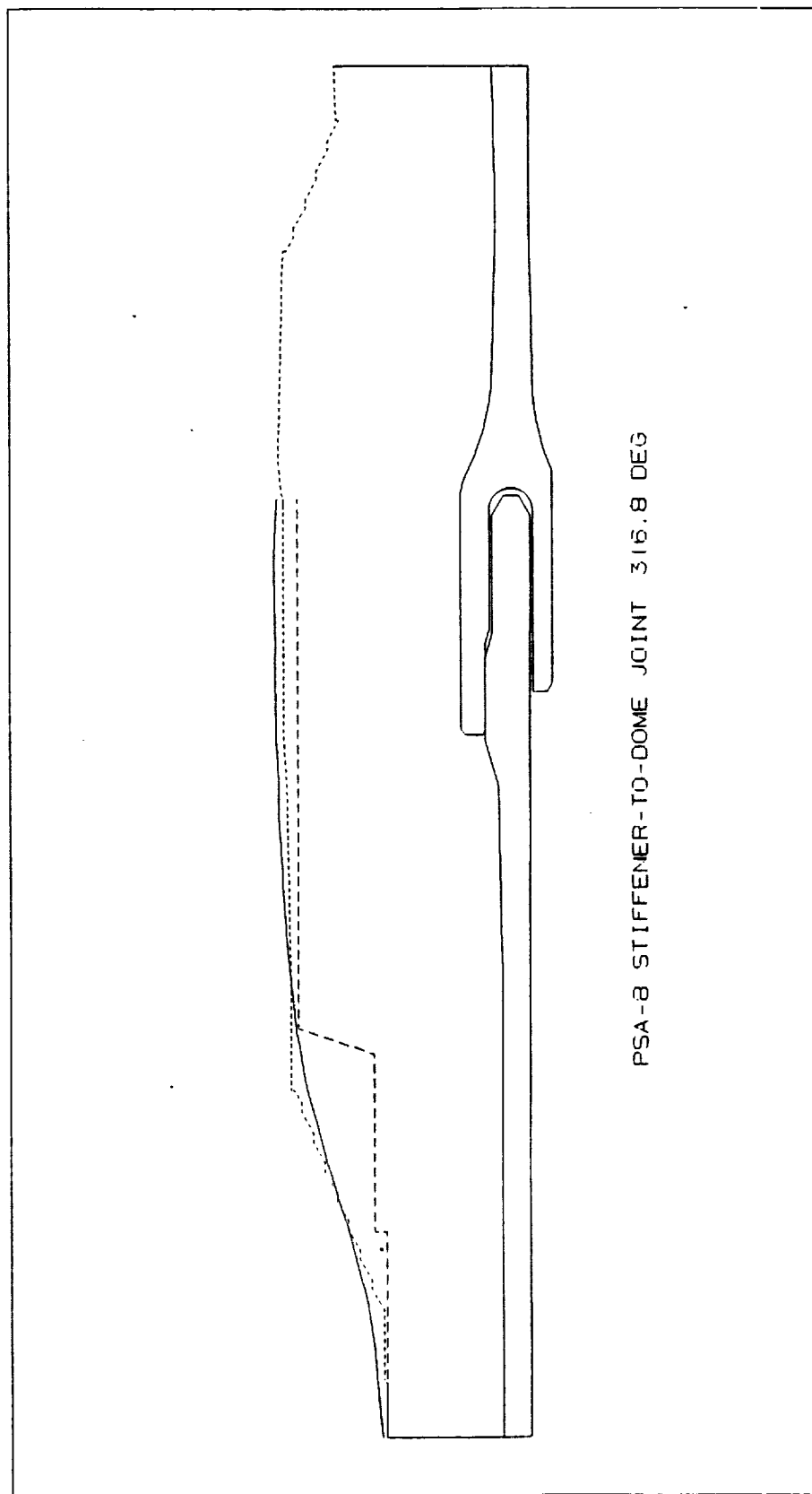
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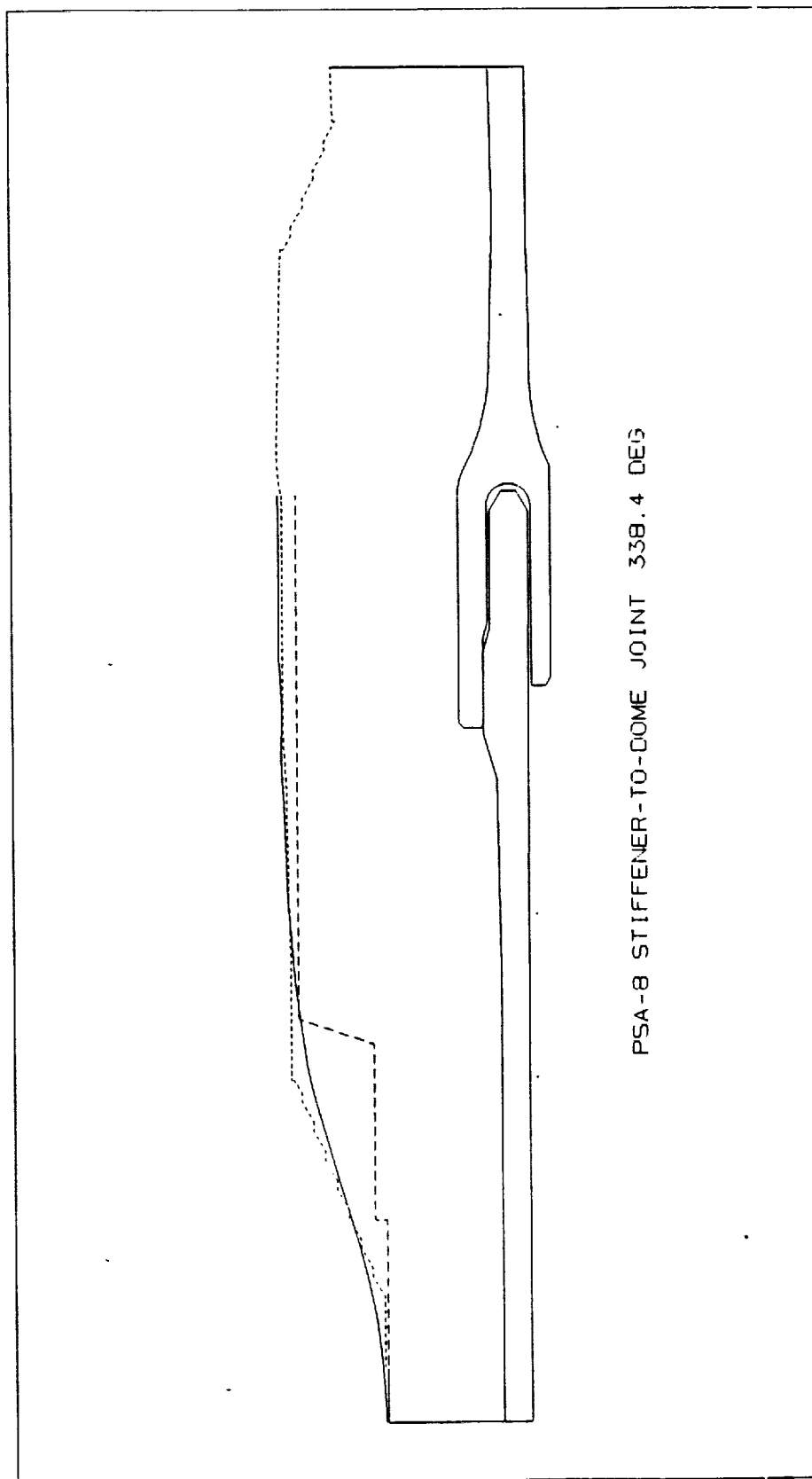
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Appendix B. Pin Gage Profiles (Continued)



Appendix B. Pin Gage Profiles (Continued)



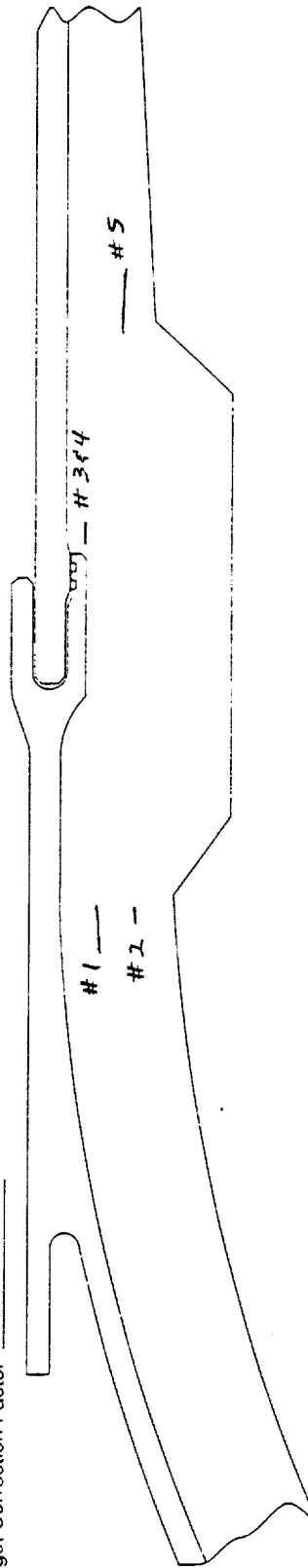
Appendix D. Dissection Void Data Sheet

AFT SEGMENT, FACTORY JOINT, DISSECTION VOID DATA SHEET

SERIAL NO 0000001	PART NO 7U77428-01	PART DESCRIPTION AFT INSUL. SEG	GROUP LEADER/FOREMAN REVIEW	DATE 12 MAR. 1991
SPECIFICATION	WORK ORDER	PROJECT	FLIGHT DESIGNATION PSA-8	DR NUMBER

FILM ID.				DISCREPANCY DIMENSIONS							SIZE		
FILM POSITION	INSP TYPE	APPROX. DEG LOC	1 DEFECT NUMBER	2 TO CASE I.D.	3 TO INS I.D.	4 FWD/AFT	FROM INNER CLEVIS LEG TIP	5 CASE + TOTAL INS.		7 LENG. (LONG)	8 WIDTH (CIR)	9 DEPTH (RAD)	COMMENTS
			247	1.05	1.95	AFT	10.40	A	N/A	1.5	1.0	0.020	
			240	2.07	0.30	AFT	10.50	S		0.45	0.20	0.020	
			291	N/A	3.24	FWD	0.20	S		0.60	0.40	0.020	
			300	N/A	3.20	FWD	0.30	S		0.40	0.50	0.020	
			15	1.65 AFT FWD 1.80 FWD FWD	N/A	FWD	8.20	N/A	N/A	1.90	0.20	0.020	

Target Correction Factor _____



- Defect number.
- Defect to case O.D. at point closest to case.
- Defect to insulation at closest point.
- Defect FWD or AFT of factory joint.
- Distance to nearest point of defect from factory joint tang.
- Total insulation thickness measured from case O.D. to insulation I.D.
Note: Give total insulation for both ends of defects located by joint hardware. "A" all end and "B" lwd end.
- Length (Longitudinal).
- Width (Circumferential extent).
- Depth (Radial) maximum defect thickness perpendicular to case.